

PROFITABILITY ASSESSMENT OF FURROW IRRIGATED MAIZE PRODUCTION IN SEMI-ARID AREA OF MAIDUGURI, BORNO STATE, NIGERIA

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ABSTRACT

Water scarcity due to the impact of climate change and the increasing global demand for water from many sectors including agriculture, has become a global concern especially in semi-arid regions where irrigation is the only alternative for crop production. The aim of this study was to determine the profitability of furrow irrigation method for maize production in a semi-arid environment of Nigeria. Two field experiments were conducted in the 2014 and 2015 seasons at the Teaching and Research Farm of Ramat Polytechnic Maiduguri, Borno State, which is located in the semi-arid region of North-Eastern Nigeria. The result shows that the total cost of production range from 259.51 to 297.31 \$/ha. The fixed costs per hectare was 194.6 to 198.8\$/ha. The variable costs per hectare was 64.91 to 98.51\$/ha. The variable costs for tensiometer and pan were similar (98.51\$/ha) while that of fixed irrigation interval of 7 days was 64.91\$/ha. Fertilizer and water application costs accounted for 9.1 to 13.8% and 41.3% to 48.3% of the total variable cost respectively. The total revenue of the whole enterprise ranged from \$435.3 to \$843.1. The total revenue for the tensiometer and the ratio of irrigation amount stood at 843.1\$/ha and 825.1\$/ha respectively, while that of fixed irrigation interval (7 days) stood at 435.3\$/ha. The net farm income and benefit cost ratio of \$545.8 and 2.84 were obtained for the Tensoiometer technique. It is recommended that efforts aimed at reducing the cost of fuel such as adhering to recommended agronomic practices of irrigation scheduling and intervals should be promoted. Markets for irrigated products should also be established with modern facilities to encourage farmers in the profession.

Keywords: Profitability, Furrow irrigation, Maize, Semi-arid areas

1 INTRODUCTION

Water scarcity due to the impact of climate change and the increasing global demand for water from many sectors including agriculture, has become a global concern especially in semi-arid regions where irrigation is the only alternative for crop production to meet the demand for food for the rapidly growing population [1]. Maize is one of the most abundant food crops in Nigeria. Man and animals consume about 80% while 20% is utilized in various industries processed for production of starch, oil high fructose, corn sweetener, ethanol, cereal and alkaline. Maize consists of 71% starch, 9% protein and 4% oil on a dry weight basis [2]. Introduced in Nigeria in the 16th century, maize is the fourth most consumed cereal ranked below sorghum, millet and rice [3]. It is the

third most important cereal after sorghum and millet [4]. It has been recognized to be one of the longest ever-cultivated food crops. Maize is also grown in several regions of the world and is referred to as the world best adapted crop [5]. In Nigeria, the demand for maize is increasing at a faster rate daily [6]. This may be due to the fact that the grain is being used for feeding poultry and also serve as the main food for many households [7]. Despite the economic importance of maize to the teeming populace in Nigeria, it has not been produced to meet food and industrial needs of the country [2]. In addition to its cultivation during the rainy season, Maize production in the semi-arid region of Nigeria relies widely on irrigation. This is due to the extremely irregular rainfall, to the extent that the amount and distribution in space and time had not been ideal to optimally support crop production adequately. Hence, irrigation agriculture is crucial to the economy, it is too important to be marginalized as it is vital for world food security [8]. Irrigation is therefore regarded as a powerful factor in increasing crop productivity, more stable incomes and employment and for increasing prospects for multiple cropping and crop diversification [9]. Compared to rain fed system, maize productivity in irrigated system is higher despite the use of fewer input implying irrigation [10]. Most of the water is applied by traditional surface irrigation methods (basin, border and furrow) to irrigate crops [1]. This might not be unconnected with the fact that Nigeria has long been beset with poverty. According to [11], 46% of Nigerian people live in poverty. The benefits of irrigation have resulted in lower food prices, provision of employment, more rapid agricultural and economic development [8]. The spread of irrigation has been a key factor behind the near tripling of global grain production [8]; therefore, there is a need for a critical assessment of the performance of irrigation farming in the study area in order to achieve more benefits from irrigation. Despite the low yield and low net farm income associated with this method when compared with other methods such as drip and sprinkler irrigations, majority of our farmers still rely on furrow irrigation method [1]. This is because most of them are resource poor and cannot afford the cost associated with drip and sprinkler irrigation methods. Thus, there is a growing gap between the demand for maize and its production to meet the food requirement for the growing population in the region. The aim of this study was to determine profitability of furrow irrigation method for maize production for semi-arid environment of Nigeria.

2 MATERIALS AND METHODS

Two field experiments were conducted in the 2014 and 2015 seasons at the Teaching and Research Farm of Ramat Polytechnic Maiduguri, Borno State which is located in the semi-arid region of Northern Nigeria. The experiments consisted of a factorial combination of scheduling methods laid in a randomized complete block design that resulted in nine (9) treatments. Irrigation scheduling methods were at three levels namely fixed irrigation interval (7days), soil moisture-based schedule using tensiometer at trigger level of 30 cbar and climate-based schedule based on the ratio of irrigation amount to cumulative pan evaporation of 1 (1.0 IW/CPE). The treatments were randomly assigned to plots and replicated 3 times. A total of 9 experimental plots were used for the study.

2.1 Furrow Irrigation System

The field layout for the furrow irrigation used for the research is presented in figures 1 and 2. The field was harrowed and ridges were constructed manually using a furrow opener at a spacing of 0.75m based on the recommended [5] spacing for maize production in the region. A total of nine (9) experimental plots were marked out for the experiment. Each experimental plot was 15m² consisting of 4 ridges of 5m long each. A ridge was used to separate a plot from the one adjacent to it. The

lengths of the furrows were limited to 5m because of the size and shape of the experimental field.

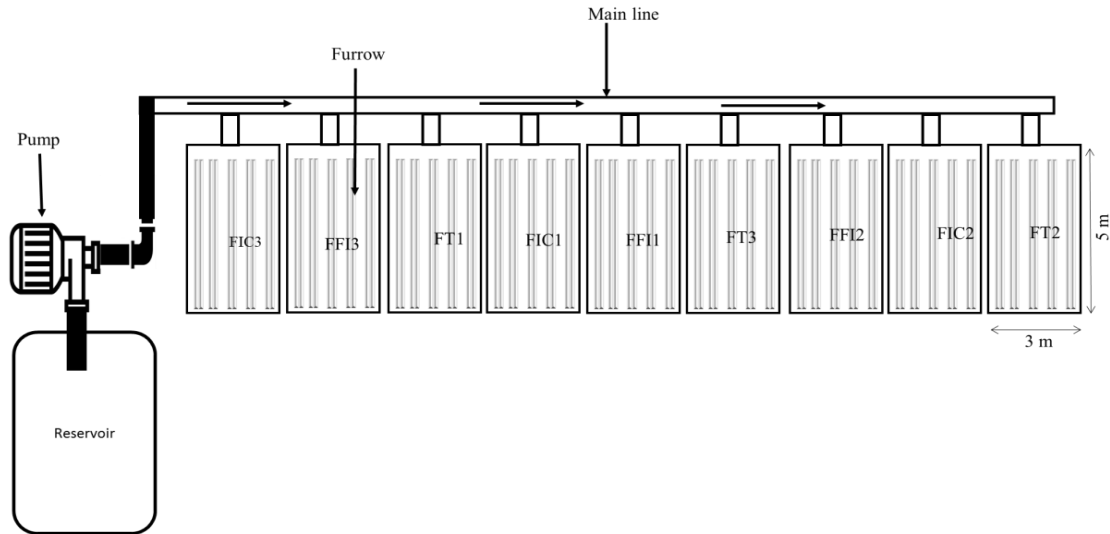


Figure 1. Field Layout of Furrow Irrigation Method



Figure 2. Furrow irrigation plots at Ramat Polytechnic research farm, Maiduguri

2.2 Irrigation Schedule

The exact amount of water [1] required by the maize crop was applied using different irrigation intervals based on the use of tensiometer, pan evaporation and fixed irrigation interval. Irrigation was carried out in the plots monitored by the tensiometer whenever the trigger level of 30cb is reached. The choice of 30cb as the trigger level was based on the research findings of [12, 13] where both reported optimum yield and water use efficiency of maize at 30cb. The evaporation pan used was the standard class A evaporation pan made from galvanized iron and is 120.5cm in diameter and 25 cm deep filled with water to a depth of 20cm. The crops were irrigated based on the ratio of irrigation amount (IW) to cumulative pan evaporation (CPE) that is IW/CPE ratio. Daily records of pan evaporation data were taken from the class A evaporation pan located in the research farm and irrigation was carried out at 1.0 IW/CPE ratio for optimum yield. The choice of the ratio of IW/CPE of 1 for scheduling maize in this work was based on the findings of previous research which shows higher yield and water use efficiency values when irrigation was scheduled at the ratio of IW/CPE equals to 1 [14]. A fixed irrigation interval of 7 days was used for irrigating the maize crop under all the different irrigation systems based on the traditional irrigation cycle used by the farmers.

2.3 Determining the Performance of the Farm Enterprises

The methods used in determining the performance of a farm business include farm profitability analysis, net farm income analysis, gross margin analysis and benefit cost ratio [15]. Farm profitability involves subtracting from the total returns the total costs of production to arrive at the profitability index. A positive value indicates that some profits are realized from the investments. The net farm income was calculated using an equation used by [16].

$$NFI = TR - TC \quad (1)$$

Where NFI = Net Farm Income from production per hectare., TR = Total Revenue>Returns from production per hectare, TC = Total Costs of production per hectare.

2.4 Benefit cost ratio

The benefit cost ratio (BCR) which is the ratio of the present value of benefit and the present value of cost was determined using equation (2).

$$BCR = \frac{Benefit}{Cost} \quad (2)$$

These were performed by identifying all costs incurred and the total revenue obtained from the production and schedules used in the study. All costs were classified as either fixed or variable cost. Costs that were incurred due to land hiring, land preparation, seed, fertilizer, water used, fuel, rented pump, rented water reservoir were classified as fixed costs while costs that were incurred due to water application, planting, fertilizer application, weeding, harvesting and threshing were classified as a variable costs. The variable costs and fixed costs were summed up to arrive at the total production cost for the research. The total revenue was obtained by quantifying the yield in monetary terms. The two costs of production and selling price (total revenue) were compared to evaluate the economic viability of different irrigation methods and techniques for maize production. The net farm income and benefit cost ratio and were determined using the procedures outlined by [17, 18, 15] as shown in equations 3 and 4 respectively.

2.5 Costs of Production

Costs of production are generally classified into fixed costs and variable costs. To facilitate the calculation of net farm income and benefit cost ratio which were used to determine the profitability and economic viability of the different irrigation methods and schedules, the different cost items were identified, quantified and the amount involved in their use in the maize production were summed up and subtracted from the total returns. The following are the different costs and the various procedures used in getting the value of their worth in the maize cultivation under furrow irrigation method.

2.5.1 Land Hiring

As most of the land used for irrigation by the farmers was rented, the average rent value per hectare was used. In some areas the farms are not clearly divided into hectareage and so the value is not accordingly charged on per hectare basis rather, for the whole farm land. In such cases, the total amount paid for the farm land is divided by the number hectares to arrive at its rent per hectare basis. The land rent per hectare therefore, was determined using equation (3).

$$LR = \frac{LP}{FLS} \quad (3)$$

Where LR = Land Rent per hectare, LP = Land Payments, FLS = Farm Land Size (Hectares).

2.5.2 Land Preparation

This involves clearing the land and then using farm tools or machines to harrow, till as well as making the land suitable for irrigation purpose. For each particular farm operation, a specific amount is paid for carrying out such activities. The total amount paid for all of these activities divided by the total hectareage of the farm is the per hectare cost for land preparation. This was arrived at using equation (4).

$$LPC = \frac{TALP}{FLS} \quad (4)$$

Where LPC = Land Preparation cost per hectare, TALP = Total Amount Paid for the various Land Preparation activities, FLS = Farm Land Size (Ha).

2.5.3 Seed Cost

In order to arrive at the seed cost per hectare, the total quantity of seed used was multiplied by the seed rate. This total was then divided by the total hectares of land cultivated with maize to get the seed cost per hectare as shown in equation (5).

$$SC = \frac{TSC}{FLS} \quad (5)$$

Where SC = Seed Cost (Ha), TSC = Total Cost of Seed used, FLS = Farm Land Size (Ha)

2.5.4 Cost of Fertilizer

Different types of fertilizer command different prices in the market and the total quantity used by a particular farmer influences his/her total cost of production. The total amount expended on fertilizer was divided by the total land size to arrive at the cost of fertilizer per hectare as shown in equation (6).

$$FC = \frac{TCF}{FLS} \quad (6)$$

Where FC = Fertilizer Cost per hectare, TCF = Total Cost of fertilizer used, FLS = Farm Land Size (Ha).

2.5.5 Cost of Fuel

This is the amount expended on the fuel used to run the water pump. It was calculated by summing all the amount of money spent on fuel which was then divided by the total hectareage of maize farm to arrive at the fuel cost per hectare using equation (7).

$$FUC = \frac{TAF}{FLS} \quad (7)$$

Where FUC = Fuel Cost per hectare, TAF = Total Amount spent on fuel, FLS = Farm Land Size (Ha).

2.5.6 Rented pump

This is the amount paid for the use of water pump to irrigate the farm under maize cultivation. The total amount paid as rent for the use of pump was summed and divided by the total hectareage of the Maize farm using equation (8).

$$RP = \frac{TRC}{FLS} \quad (8)$$

Where RP = Rent of Pump per hectare, TRC = Total Rental Cost, FLS = Farm Land Size (Ha).

2.5.7 Water used Cost

The area of study being in the semi-arid region of the country is an area with a scarcity of water. For this reason, the total quantity of water used was quantified and costed based on the average prevailing water rate using equation (9).

$$WCH = \frac{WUC}{FLS} \quad (9)$$

Where WUC = Total quantity of water used x average water rate, WUC = Total Cost of Water Used by the farmer, WCH = Cost of Water per hectare, FLS = Farm Land Size (Ha).

2.5.8 Rented Water Reservoir Cost

Water need to be reserved in some type of container before ultimately being used for irrigating the maize crops. While some farmers purchase large plastic containers others use concrete

water reservoirs. The reservoir is normally rented for the period of cultivation. The cost of renting the reservoir was arrived at by dividing the total cost of rented reservoir by the number of hectares cultivated to convert to per hectare basis using equation (10).

$$RWR = \frac{TRC}{FLS} \tag{10}$$

Where RWR = Water Reservoir Rent per hectare, TRC = Total Rental Cost, FLS= Farm Land Size.

2.5.9 Labour Cost

Labour costs were incurred for carrying out the different cultural practices such as planting; fertilizer application, weeding, harvesting, threshing etc. involved in the maize production activities. The total amount of money expended on each of these operations were calculated and divided by the size of the farm in hectares to get their per hectare values. For instance, water application cost per hectare is the total amount per water application divided farm size in hectares. For planting operation cost per hectare, it is the total cost of planting divided by farm size in hectares. For fertilizer application cost per hectare, it is the total cost for applying fertilizer divided by farm size in hectares. For weeding cost per hectare, it is total amount spent on weeding divided by farm size in hectares. For harvesting cost per hectare, it is total amount spent on harvesting divided by farm size in hectares. For threshing cost per hectare, it is total amount spent on threshing divided by farm size in hectares. The total for each of these activities on per hectare basis was the cost expended on labour for maize production per hectare.

3 RESULTS AND DISCUSSION

The results of the total cost involved are presented in Table 1. The result shows that the total cost of production range from 259.51 to 297.31 \$/ha. The variable costs per hectare was 64.91 to 98.51 \$/ha. The variable costs were higher in pan and tensiometer irrigation techniques with shorter irrigation interval (4days) which resulted in higher cost of fuel and water application compared to the fixed irrigation interval of 7 days. Fertilizer and water application costs accounted for 9.1% to 13.8% and 41.3% to 48.3% of the total variable cost respectively. The cost of fertilizer accounted for 72.5% to 74.0% of the fixed costs.

Table 1. Total cost involved in maize production under furrow irrigation method and schedules

Items	Furrow Fixed	Tensiometer	IW/CPE
Inputs			
Fixed Costs (FVC)			
Land hiring	10.71(4.13)	10.71(3.60)	10.71(3.60)
Land preparation	17.86(6.88)	17.86(6.01)	17.86(6.01)
Seed	4.76(1.83)	4.76(1.60)	4.76(1.60)
Fertilizer	144.05(55.5)	144.05(48.5)	144.05(48.5)
Rented pump (1.5 hp)	5.32(2.05)	9.52(3.20)	9.52(3.20)
Rented water reservoir	11.9	11.9	11.9
Total fixed costs	194.6	198.8	198.8
Variable Costs			
Water used	5.69(2.19)	10.12(3.40)	10.12(3.40)
Water application	26.79(10.3)	47.62(16.00)	47.62(16.00)
Fertilizer application	8.93(3.44)	8.93(3.44)	8.93(3.44)
Fuel	10.71(4.13)	19.05(6.41)	19.05(6.41)
Weeding	4.46(1.72)	4.46(1.50)	4.46(1.50)
Harvesting	4.76(1.83)	4.76(1.60)	4.76(1.60)
Threshing	3.57(1.38)	3.57(1.20)	3.57(1.20)
Total variable costs	64.91	98.51	98.51
Total Cost of production	259.51	297.31	297.31

Table 2. Net farm income for maize production under furrow irrigation method and schedule

Items	Furrow Fixed	Tensiometer	IW/CPE
Output			
Yield (kg)	2176.7	4215.3	4125.7
Unit price/100kg	20	20	20
Total revenue	435.3	843.1	825.1
Total Cost	259.51	297.31	297.31
Net farm income	175.8	545.8	527.3
Benefit cost ratio	1.68	2.84	2.78

The total revenue obtained using furrow irrigation method is presented in Table 2. The tensiometer and the ratio of irrigation amount to cumulative pan evaporation techniques gave higher total revenue when compared with the fixed irrigation interval (7 days). The result further revealed that the net farm income and benefit cost ratio of \$545.8 and 2.84 respectively were obtained for the Tensiometer technique.

4 CONCLUSIONS

The study analyzed the cost and return in furrow irrigated maize production. The furrow method of irrigation often requires high-capacity water pumping machines to distribute water over relatively large plots. It may also require land-clearing machinery or draft animals (or both) for grading and leveling plots. Land used for furrow irrigation should have soil with high infiltration rates, a fairly smooth surface, and relatively large, rectangular-shaped, and un-fragmented plots. Soil erosion is common for furrow irrigation systems, with negative impacts on long-term productivity. However, with net farm income and benefit cost ratio of \$545.8 and 2.84, maize production using furrow irrigation method is profitable and worth undertaking. Efforts aimed at reducing the cost of fuel such as adhering to recommended agronomic practices of irrigation scheduling and intervals should be promoted. Favorable market conditions for irrigated products may be needed to achieve adequate returns and encourage farmers to adopt furrow irrigation.

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